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Main Research Topics:

- Gamma-ray burst (GRB) observations and analysis. Comparative studies of GRBs detected by multiple spacecraft. Detailed studies of individual GRBs.
- Galactic black hole binary observations. Comprehensive multiwavelength analysis of black hole systems in outburst. Searches for undiscovered galactic black hole transients.
- Supergiant Fast X-ray Transient (SFXT) observations. Study of hard X-ray flares in eleven SFXTs observed over eight years.
- High-mass X-ray binary observations. Determination of super-orbital periods from mutli-year X-ray light curves.

Most Relevant Programmatic Skills:

- Astronomy data analysis support: software development, writing, testing and documentation; calibration data base development; technical document writing; data verification and archiving.
- Astronomical event and image data correction: application of coordinate transformations, aberration and barycenter corrections, data cleaning and gain correction.
- Data processing pipeline: conception, creation and archiving of light curves for 1000 astronomical sources using X-ray data from the Swift Burst Alert Telescope.
- Instrument development: testing and calibration of flight hardware, verification of point source reconstruction software, ground verification of proposed flight software updates.
- Balloon payload development and field campaign experience: wide-ranging participation related to alignment, star tracking, instrument balance, ground station support and observation planning.

Narrative Description of Research and Programmatic Work:

My research covers a broad range of topics in X-ray astrophysics, with the unifying theme that most of it is based on analysis of data from the Swift/Burst Alert Telescope (BAT). Among my papers on BAT-detected gamma-ray bursts (GRBs), Krimm *et al.,* 2007, Ap. J, **665**, 554, advances the understanding of late GRB flares by proving that the long series of flares in GRB 060714 show light curve morphology, spectral evolution and rapid variability, quite similar to the prompt emission, effectively ruling out an external shock origin for the flares. Another work (Krimm *et al.,* (2009), Ap. J., **704**, 1405), written with members of the Suzaku/Wide-band All-Sky Monitor (WAM) team, presents a detailed catalog of 91 GRBs detected by both BAT and WAM, extending the energy range from 15 to 5000 keV and confirming that Swift bursts and their individual pulses are consistent with earlier reported relationships between the peak energy and isotropic energy. Additionally I contributed to the series of BAT GRB catalog papers (e.g. Sakamoto *et al.,* (2011), Ap. J.S., **195**, 2) and to the InterPlatenary Network for GRBs (e.g. Hurley *et al.,* (2013), Ap. J.S., **207**, 39).

My discovery of 20 new transient X-ray sources with the Swift/BAT transient monitor (Krimm et al, 2013, ApJS **209**, 14) has expanded my research to include the phenomenology of variable galactic binary sources, in particular black-hole transients. One of the first BAT monitor discoveries was the accretion-powered millisecond pulsar Swift J1756.9-2508 (Krimm *et al.,* (2007), Ap. J, **668**, L147), which was determined to be a neutron star in binary orbit with a low-mass white-dwarf companion, which has been reduced by mass-loss to a He-rich core. This result was the subject of a NASA press release
(http://www.nasa.gov/centers/goddard/news/topstory/2007/millisecond_pulsar.html).
Also discovered in the transient monitor was Swift J1539.2-6227 (Krimm *et al.,* (2011), Ap. J., **735**, 104), which was found to be strong black hole candidate based on the progression of spectral states and strong quasi-periodic oscillations observed over 176 days with Swift and the Rossi X-Ray Timing Explorer (RXTE). The remaining BAT monitor discoveries through 2013 are presented with basic analysis Krimm et al, 2013, ApJS **209**, 14, which also describes the monitor process in detail. Many papers on these sources have been published by other authors, including Swift J2058.4+0516, a likely relativistic tidal disruption flare (Cenko, Krimm *et al.,* (2012), Ap. J., **753**, 77) and the dynamically confirmed low-luminosity black hole Swift J1357.2-0933 (e.g. Corall-Santana *et al.* (2013), Sci **339**, 1048).

I have also contributed to an extensive list of papers led by others. I have a strong collaboration with Patrizia Romano of the Italian Istituto Nazionale di Astrofisica (INAF) to study supergiant fast X-ray transients (e.g. Romano *et al.,* (2014), A. & A., **562**, 2) and with Robin Corbet of NASA/GSFC to investigate superorbital periods of high-mass X-ray binaries using BAT data (Corbet and Krimm (2013), Ap. J., **778**, 45). I have contributed BAT data to multi-wavelength observational campaigns on objects as diverse as flare stars (Osten *et al.,* (2010), Ap. J., **721**, 785), galactic black hole binaries (Kennea *et al.,* (2011), Ap. J., **736**, 22) and active galactic nuclei (Soldi *et al.,* (2014), A. & A., **563**, 57).

I am a member of the Hitomi (Astro-H) Software and Calibration Team (SCT) and the U.S. lead data scientist for the Hitomi Hard X-ray Imager (HXI) and Soft Gamma Detector (SGD). I have worked with a group of nine scientists in the U.S. and Japan and seven scientific programmers to develop analysis software and calibration products for the Hitomi mission. The SCT has produced ground scientific analysis software for the data-processing pipeline and or the end-user within the FTOOLS package of the NASA High Energy Astrophysics Science Archive Research Center (HEASARC), calibration products within the HEASARC Calibration Database (CALDB) framework, and science data products for the HEASARC.

I was responsible for eleven Hitomi FTOOLS, which are used both in the ground science data analysis pipeline and by the end scientific user. These include a suite of coordinate transformation software and tools that use the data from the Hitomi laser alignment system to correct for motion of the extensible optical bench. I also helped develop the tools to reconstruct the data for the HXI and SGD. For each tool, after producing an initial software requirements document, I worked in tandem with a code developer, revising the document as needed, extensively testing the developing code using simulated and ground calibration data, and writing the help file and unit tests for the tool. After delivery, I continued to work with the same developer to fix bugs and add enhancements as needed.

In developing this software, I became quite familiar with the conceptual and mathematical basis of astronomical image coordinate manipulation and calculation. In particular, I derived a good understanding of coordinate transformations, quaternion arithmetic, use of spacecraft attitude knowledge to correct images, stellar aberration correction and adjustment of photon event timing to a reference at the Solar System barycenter. Although the specific issues I encountered and resolved were for astronomical X-ray image data, the techniques are applicable to any astronomical image or event data.

My Hitomi tasks also included developing and maintaining the CALDB products associated with the software under my direction. For example, the coordinate transformation software relies on a Telescope Definition (TelDef) file for each instrument, which I created based on design and calibration data from the relevant Instrument Teams and knowledge of their use in the software.

I am also responsible, in whole or in part, for several analysis documents, including a complete description of the Hitomi coordinate systems, a technical reference for the SGD, and the user guide to data analysis. Finally, I helped to verify the data, from the ground and early in the flight. This was a large and detail-oriented job, which included work ranging from careful validation of each keyword, column descriptor and file format, to high-level examination of the spectra, light curves and images derived from the event data. This work helped me became familiar with pipeline data processing and archiving.

For the Swift/BAT instrument, I devised, created, developed and continue to maintain the Swift/BAT Hard X-ray Transient Monitor (Krimm et al, 2013, ApJS **209**, 14). This is a web-based resource (http://swift.gsfc.nasa.gov/results/transients), which has become an important reference for any in the astronomical community concerned with variable hard X-ray objects. The monitor, which began operations in 2006, includes X-ray light curves for over 1000 objects known or believed to be X-ray sources, nearly 300 of which have been detected in the BAT on a time scale of one day or shorter.

After the BAT GRB response and all-sky survey, the BAT monitor is the most used BAT product. There are 90 refereed citations to the 2013 monitor article and the initial monitor announcement, and many other papers have made use of the monitor results over the past ten years. I have leveraged this work into a number of fruitful collaborations, and most of my non-GRB publications involve my use of BAT monitor data. I have discovered 20 new hard X-ray transients, and have submitted 68 successful Swift Target of Opportunity observations and authored over 200 Astronomer's Telegrams, mostly based on monitor detections.

The monitor is completely automated and I developed the entire process, with programmer assistance only with two specific and limited parts of the task. The script runs hourly as a combination of standard Swift FTOOLS and custom IDL programs to create source-specific light curves placed on a public web host. The script also creates sky image mosaics, which are used to search for previously undiscovered transient X-ray sources. My work on the monitor was initially supported by a series of five Swift Guest Investigator (GI) grants, but after the expiration of the last of these grants, I have continued to maintain the monitor as an overload on my programmatic responsibilities. I have edited the Transient Monitoring section for each of the Swift Senior Review proposals.

Prior to the Swift launch, I worked with the Swift/BAT Instrument Team to test and calibrate the BAT instrument, starting from the individual detector modules (DMs), through the blocks (eight DMs) and finally the full instrument (16 blocks). I used a set of different radioactive sources at varying orientations to calibrate the energy response as a function of incident angle. I helped develop the algorithms to convert the results into calibration products. Since the BAT positional reconstruction code had been written to accommodate a finite source distance, I was able to verify this algorithms using radioactive sources ~10 meters above the array in a high bay. I participated in round-the-clock shifts during BAT integration and testing, both at Goddard Space Flight Center (GSFC) and Kennedy Space Center (KSC) and during launch and early orbit checkout. I continue as a member of the science support team, fielding questions from science users and serving as a BAT technical advisor for several proposal reviews.

I also worked on software development for Swift/BAT, with particular emphasis on tools to clean background and bright sources from BAT images, apply gain and offset corrections to BAT event data, and to produce background-subtracted light curves. I have continued to support these tools throughout the mission. I am also the principal scientist in charge of verification of proposed modifications to the BAT flight software. For each such change, the developers run a set of simulations designed to verify each part of the flight software. My task is to carefully analyze the results of these simulations and compare to a baseline to ensure that the changes both produce the desired output and cause no damage to existing code.

As a Swift team member, I take 24-hour call several times a month for response to gamma-ray burst (GRB) alerts. Upon an alert, I work with an international team to rapidly verify the GRB (or determine that the alert is a false alarm) and draft a circular for distribution through the Gamma-ray Coordinates Network (GCN). I also regularly serve as burst advocate, reporting on an assigned GRB at the daily mission planning telecom.

Another project from earlier in my career at GSFC (1999 - 2011) was the InFOCμS balloon program, designed as a hard X-ray imaging telescope (a precursor to NuStar) and flown several times from Palestine, TX and Fort Sumner, NM. My work on this project covered a wide range of electrical, mechanical and scientific tasks and participation in each of four field campaigns during this period. Some of the highlights of my work were upgrading the ground station software, devising the in-flight observing plan, calibration and testing of the star trackers, developing the laser alignment system, balancing the momentum wheels, and analyzing flight data. I worked on mundane tasks such as ordering parts, designing and sometimes building cable harnesses and balancing the instrument, as well as high-level tasks such as significant contributions to all InFOCμS proposals during my tenure. I also supervised several undergraduate students on this project.

My service to Goddard beyond the science programs has been extensive and varied. I am a radioactive source custodian for nearly 60 sources used on the Swift and InFOCµS programs and other ongoing development efforts in the lab. I am a wing warden for fire and other emergency evacuation needs in Goddard Building 34. I contribute regularly to the GSFC Ask an Astrophysicist service, fielding astronomy questions from interested students and adults from all over the world. My most rewarding service role is as a member of the Goddard Scientific Colloquium Committee member. I help to choose each season's slate of speakers and as CRESST representative on the committee, I am charged with sending all official invitations.